Active Light Noise Filter by a Differential Operation

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ABSTRACT

A method for an active light noise filter is proposed by using two identical light receivers. They work as a differential electrometer by a common mode connection. Therefore, only an output of a laser light incident upon one receiver can be obtained as a signal. It was found from the experiment that the light noise was reduced to about 0·6% in the usual light room and further the signal to noise ratio was improved up to 30 times at least as compared to a usual light shielding method. The method can then be effectively used under a well-lighted room such as a factory without noise light shielding cover.

1 INTRODUCTION

We have developed such laser sensors as for measuring blood leakage,[1] the thickness of a semi-transparent film,[2] dye colour and concentration,[3,4] and cloth filament.[5,6] These sensors work perfectly well in a laboratory where we can eliminate a light noise and vibration. These sensors, however, get reductions of sensitivity and accuracy at least, and at the worst they don't work well frequently because of the light noise and the vibration when they are applied in the factory. The light noise can be eliminated to a certain degree by the light shielding cover, but the vibration cannot be eliminated. In this paper, we propose a method to eliminate light noise and vibration activity in the presence of light noise and vibration by means of a differential operation and verify it by a preliminary experiment.

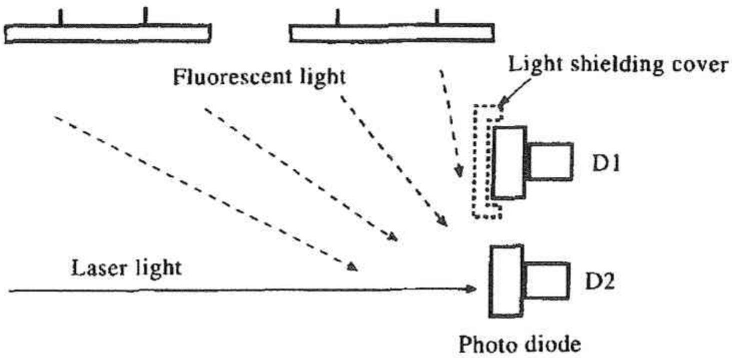

Fig. 1. Whole optical arrangement for this experiment.

2 PRINCIPLE AND METHOD

The principle is based on the differential operation of the two identical light receivers, where the laser light as a signal is received only on one receiver. Figure 1 shows the whole optical arrangement of the preliminary experiment considering the practical use in the factory. Both the noise light and the laser light are incident upon the receiver D_1 and only the noise light upon the receiver D_2. The outputs of each receiver, P_1 and P_2, are then expressed as follows:

$$P_1 = K(N_1 + L), \quad P_2 = K(N_2) \tag{1}$$

where, L shows the laser light power and K the coefficient of the receiver showing the relation between light intensity and output power. The light noise powers on both receiver are assumed to be nearly equal, $N_1 = N_2 \equiv N$, since they are positioned closely.

Figure 2 shows practical noise filter circuit which works as a differential electrometer. The total output P from both the receivers is, therefore, expressed as

$$P = P_1 - P_2 = KL \tag{2}$$

That is, we can eliminate the light noise. Further, we can eliminate an

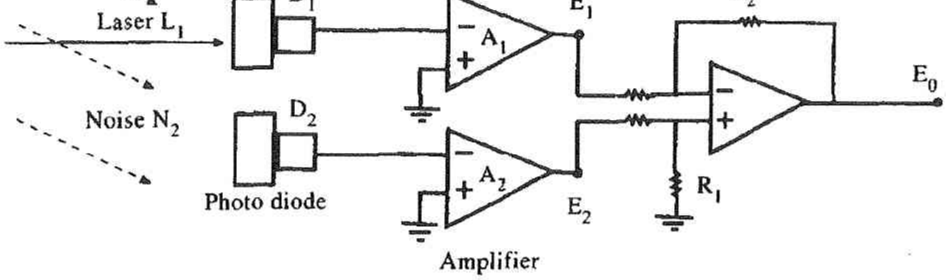

Fig. 2. Electronic circuit for differential operation.

measurement error, which reduces the accuracy and sensitivity, due to the vibration, by mounting both receiver on the same supporting structure. The method can, thus, be applied in such a well-lightened room with vibration as a factory. In this sense, we call the method as 'active light noise filter'.

3 RESULT

Figure 3 shows the output recieved on one receiver D_2. In this case, the other receiver D_1, was shielded with a light shielding cover. Figure 3(a) shows the output of the fluorescent light (2·92 V); (b) the laser light (6·58 V); and (c) the sum of fluorescent light and laser light (9·50 V). The total light power agrees quite well. This shows the linearity of the receiver (Photodiode; Hamamatsu).

Figure 4 shows the similar results as in Fig. 3(a), but with the light received on both receivers, D_1 and D_2. In this case, the electric circuit works as a differential electrometer and the output becomes different between the outputs D_1 and D_2. Only an extremely small fluorescent light power, about 20 mV, is yielded. That is, the reduction ratio of noise light power is about 0·68% (= 20/2920).

We can usually obtain the reduction ratio of about a few percent by a light shielding cover. We call it 'passive light noise filter' in contradistinction to our method 'active light noise filter'. The active light noise filter can achieve about 10 times higher reduction ratio as compared to the passive light noise filter. We can further achieve higher reduction ratio by the use of both filters. This gives us more accurate and sensitive measurements and, further, is indispensable to count a cloth filament,[5,6] where the transmitted[5] or scattered[6] laser light power as a signal is rather small as compared to a noise light power because the room is very bright to detect a defect of the cloth by human eye. As an example, the signal to noise ratio of only about 2–5 could be obtained only by a passive noise filter, but it could be improved to about 30 by both the filters. We could, then, count the cloth filament within an error of 0·2%.

4 CONCLUSION

A method of active light noise filter was proposed and verified experimentally. The method is based on the differential operation of the two identical light receivers. It was found that the method has some merits as follows:

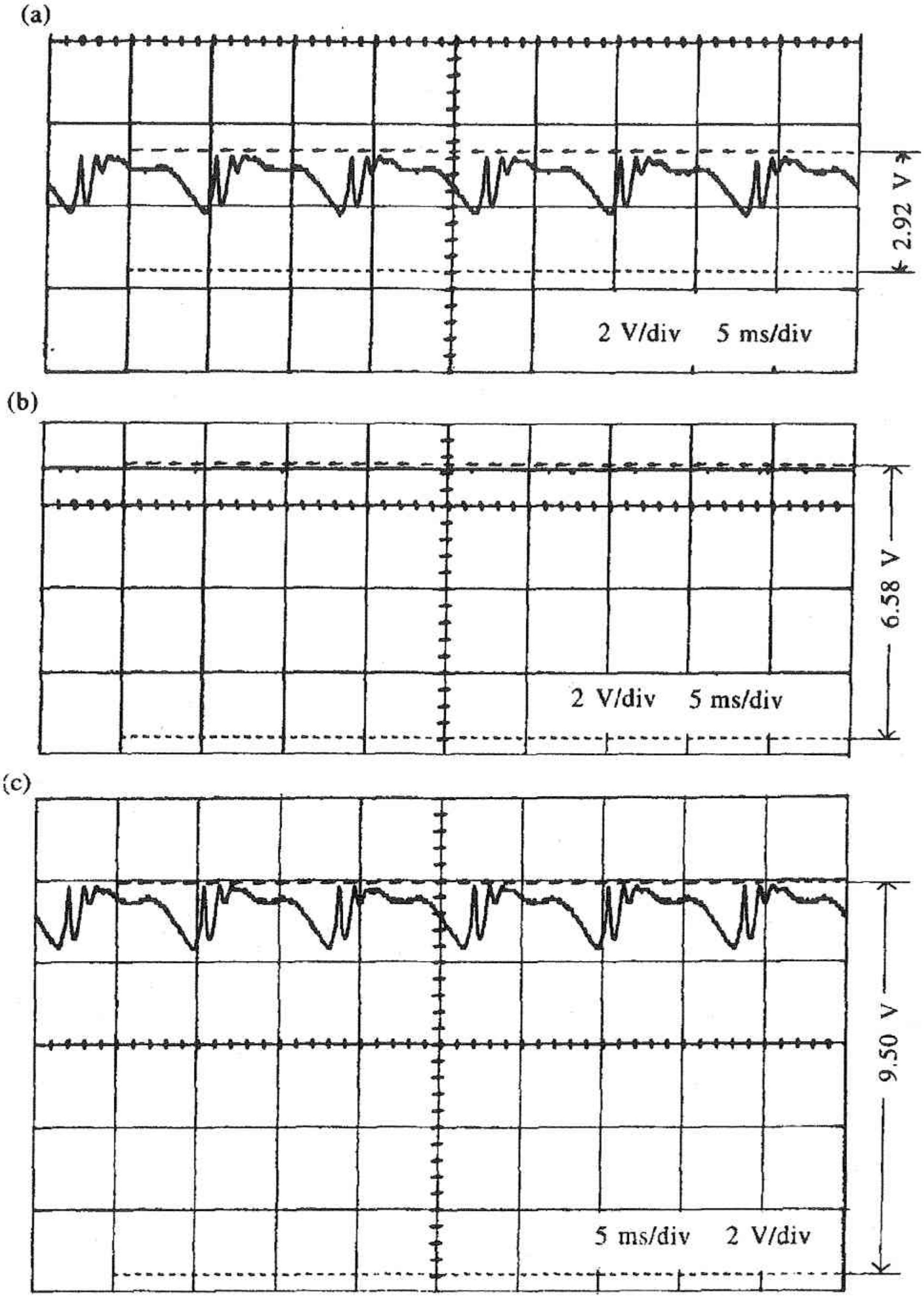

Fig. 3. The output power received on one photodiode D_2, the other being shielded by a light shield cover: (a) the power of the fluorescent light (2·92 V); (b) power of the laser light (6·58 V); and (c) power of sum of fluorescent light and laser light (9·50 V).

1. it is rather simple;
2. it can improve a signal to noise ratio to about 30 times as compared to a usual light shielding method, i.e. 'passive light noise filter';
3. it can, further, eliminate the measurement error due to a vibration which is unavoidable in the factory.

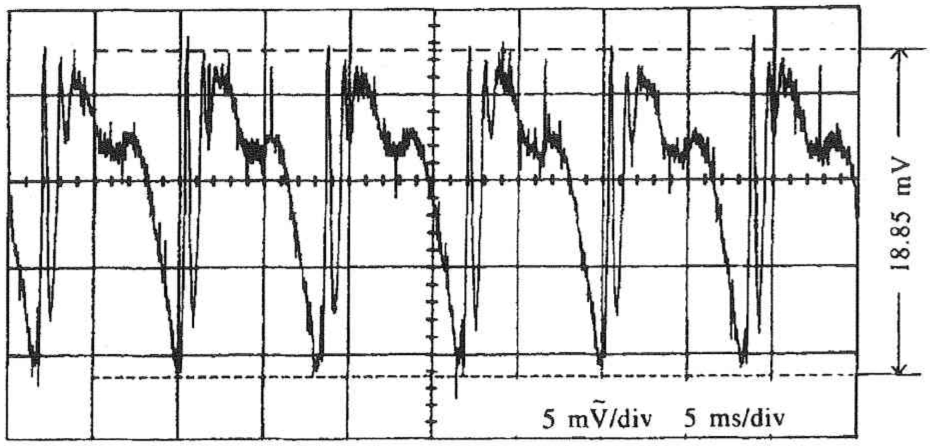

Fig. 4. The output power of the fluorescent light received on both photodiode, D_1 and D_2, simultaneously.

ACKNOWLEDGEMENT

Technical support throughout the present study was provided by Mr T. Inaki of Fukui University, Fukui, Japan.

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